MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 2, 2019/2020

ETN2016 – ANALOG COMMUNICATIONS

(All Section / Groups)

10 MARCH 2020
9.00 a.m - 11.00 a.m
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This Question paper consists of 9 pages (including the cover page) with 4 Questions only.

2. Attempt all of the **FOUR** questions. All questions carry equal marks and the distribution of the marks for each question is given.

3. Please write all your answers in the Answer Booklet provided.

Question 1

(a) Consider a periodic signal $w(t)$ shown in Figure Q1.1.

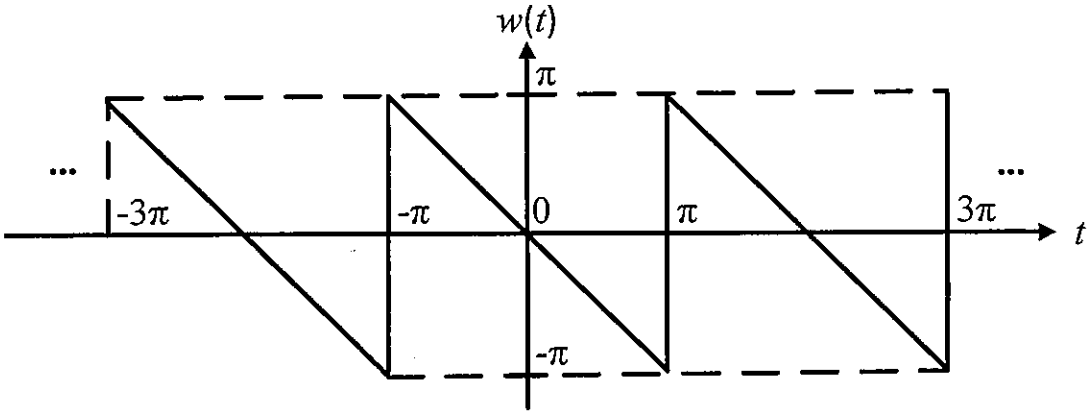

Figure Q1.1: Periodic signal $w(t)$.

(i) Determine the trigonometric Fourier series of $w(t)$.

[10 marks]

(ii) Sketch the double-sided magnitude spectrum of $w(t)$ up to the 5th harmonic, i.e., n = -5, -4, -3, -2, -1, 0, 1, 2, 3, 4, 5, where $f = nf_0$ is the nth harmonic frequency, $f_0 = \frac{1}{T_0}$, and T_0 denotes the period of $w(t)$.

[3 marks]

(iii) Sketch the single-sided phase spectrum of $w(t)$ for n = 0, 1, 2, 3, 4, 5, where $f = nf_0$ is the nth harmonic frequency, $f_0 = \frac{1}{T_0}$, and T_0 denotes the period of $w(t)$.

[3 marks]

(b) The Fourier transform of $s(t)$ is given by $S(f) = \frac{j2\pi f}{1 + j2\pi f}$. Determine the Fourier transform of the following signals:

(i) $x(t) = -s(-t)$

[2.5 marks]

(ii) $y(t) = 0.5\,s(t+2)$

[2.5 marks]

(iii) $z(t) = e^{-j2t}s(t-3)$

[4 marks]

Continued .....

Question 2

(a) Consider the double-sided magnitude spectrum of the message signal $G(f)$ illustrated in Figure Q2.1.

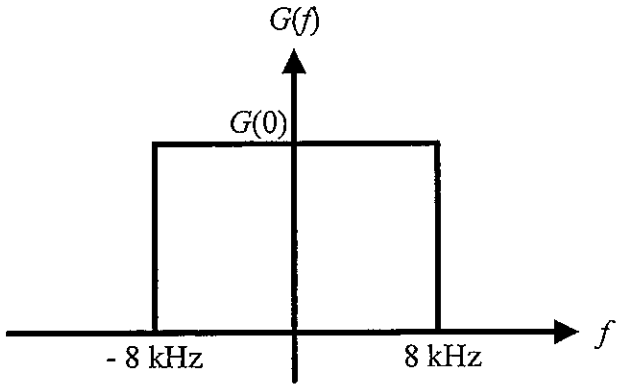

Figure Q2.1: Double-sided magnitude spectrum $G(f)$.

(i) Compute the minimum transmission bandwidth required if the double-sideband large carrier (DSB-LC) modulation scheme is used.

[2 marks]

(ii) Sketch the spectrum of the modulated signal if the double-sideband suppressed carrier (DSB-SC) modulation scheme is utilized. Assume that the amplitude and the frequency of the carrier signal are 1 V and 800 kHz, respectively.

[2 marks]

(iii) Calculate the total number of radio stations that can be simultaneously accommodated in a bandwidth of 35 kHz if all the radio stations adopt the DSB-SC modulation scheme and transmit the same message signal as shown in Figure Q2.1.

[2 marks]

(iv) State one advantage and one disadvantage of the DSB-LC modulation scheme in comparison to the DSB-SC modulation scheme.

[2 marks]

(v) Suggest two analog modulation techniques to improve the bandwidth efficiency of the DSB-SC scheme.

[2 marks]

Continued .....

Question 2

(b) A message signal $b(t)=20\cos(200\pi t)$ is applied to a double sideband large carrier (DSB-LC) modulator with carrier signal $c(t)=50\cos(800000\pi t)$. Assume that the DSB-LC modulated signal $s(t)$ is supplied to a load of 100 ohms and the total power dissipated across the load due to $s(t)$ is 16.016 W.

(i) Calculate the power contained in the lower sideband of the DSB-LC modulated signal.

[4 marks]

(ii) Compute the modulation index.

[2 marks]

(iii) Calculate the power efficiency of this DSB-LC scheme.

[2 marks]

(iv) Sketch the power spectrum of the DSB-LC modulated signal.

[3 marks]

(c) Discuss the differences between double-sideband large carrier (DSB-LC) modulation and vestigial sideband (VSB) modulation technique in terms of the spectrum of the modulated signal.

[4 marks]

Question 3

(a) Consider a frequency modulated signal that is expressed as $x(t) = A\cos\left[2\pi f_c t + B\int_0^t \cos(2\pi f_m \tau)d\tau\right]$. Determine the following expressions for $x(t)$:

(i) Message signal.

[1 mark]

(ii) Instantaneous frequency.

[3 marks]

(iii) Maximum magnitude of the frequency deviation.

[2 marks]

(iv) Modulation index

[1 mark]

Continued .....

Question 3

(b) A carrier signal is frequency modulated by a sinusoidal signal of frequency 18 kHz. Assume that the amplitude of the carrier signal is 1 V, the modulation index is 0.5 and the frequency modulated signal $g(t)$ is supplied to a load of 1ohm.

(i) By applying Carson's rule, calculate the bandwidth of $g(t)$.

[2 marks]

(ii) By applying the Table of Bessel functions of the first kind, compute the bandwidth of $g(t)$.

[2 marks]

(iii) Calculate the average power of $g(t)$.

[1 mark]

(iv) Determine the percentage of the total power contained at the carrier frequency.

[2 marks]

(v) Determine the percentage of the total power contained in the sidebands.

[2 marks]

(c) With the aid of a diagram, explain the function of limiter used in a frequency modulation system.

[3 marks]

(d) With the aid of an example, explain the capture effect that is associated with frequency modulation reception.

[6 marks]

Question 4

(a) Distinguish the differences between pre-detection signal-to-noise ratio (SNR) and post-detection SNR in communication systems and explain the importance of these parameters.

[5 marks]

Continued .....

Question 4

(b) Consider an amplitude modulation (AM) receiver shown in Figure Q4.1. The input of the envelope detector is $x(t)=s(t)+n(t)$, where $s(t)=A_c\left[1+k_a m(t)\right]\cos(2\pi f_c t)$ is the amplitude modulated signal, $n(t)$ represents white noise with power spectral density of $\frac{N_0}{2}$, $A_c\cos(2\pi f_c t)$ is the carrier signal, $m(t)$ is the message signal with bandwidth of W (Hz), and k_a is the amplitude sensitivity of the modulator. Assume that the band-pass filter has unity gain and an equivalent noise bandwidth of B_T (Hz), $E\left[m(t)\right]=0$, and $P=E\left[m^2(t)\right]$, where $E[\ ]$ is the expectation operator.

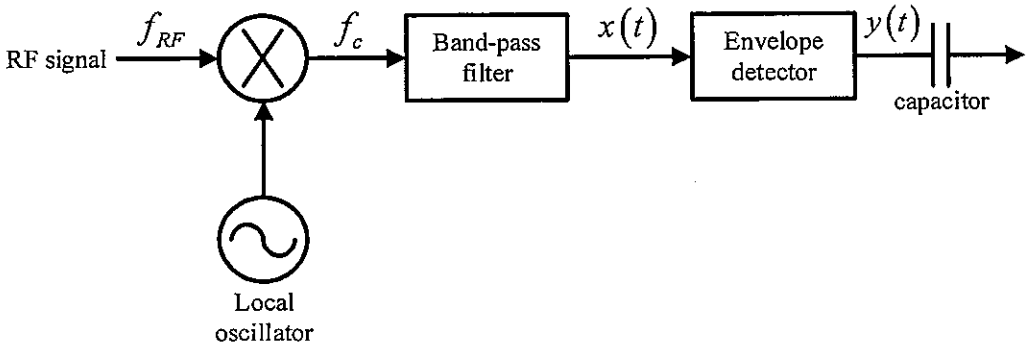

Figure Q4.1: Block diagram of an AM receiver.

Determine expressions for the following:

(i) The average power of the signal component at the input of the envelope detector. [5 marks]

(ii) The average power of the noise component at the input of the envelope detector. [2 marks]

(c) Design a superheterodyne amplitude modulation (AM) radio receiver that can be tuned to receive signals from 560 kHz to 1650 kHz. The intermediate frequency (IF) is set to 480 kHz by using low-side injection (low tracking).

(i) Calculate the required range of the local oscillator's frequencies. [3 marks]

(ii) Compute the range of image frequencies. [3 marks]

(iii) Determine the local oscillator's frequency and the image frequency when the receiver is tuned to a station at 1210 kHz. [3 marks]

(iv) Calculate the image rejection ratio (IRR) in dB if the receiver is tuned to a station at 1210 kHz, the image rejection filter has a 32 kHz passband bandwidth and 40 dB/decade roll-off. [4 marks]

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APPENDIX

Fourier Transform Pairs

$x(t)$	$X(f)$
$\delta(t)$	1
$\delta(t-t_o)$	$e^{-j2\pi ft_o}$
1	$\delta(f)$
$e^{j2\pi f_o t}$	$\delta(f-f_o)$
$u(t)$	$\frac{1}{2}\delta(f)+\frac{1}{j2\pi f}$
$e^{-at}u(t)$	$\frac{1}{a+j2\pi f}$, for $a>0$
$e^{at}u(-t)$	$\frac{1}{a-j2\pi f}$, for $a>0$
$e^{-a\lvert t\rvert}$	$\frac{2a}{a^2+(2\pi f)^2}$, for $a>0$
$rect\left(\frac{t}{T}\right)$	$T\text{sinc}(fT)$
$\text{sinc}(2Wt)$	$\frac{1}{2W}rect\left(\frac{f}{2W}\right)$
$\Delta\left(\frac{t}{T}\right)$	$\frac{T}{2}\text{sinc}^2\left(\frac{fT}{2}\right)$
$W\text{sinc}^2(Wt)$	$\Delta\left(\frac{f}{2W}\right)$
$e^{-\pi t^2}$	$e^{-\pi f^2}$
$\cos(2\pi f_o t)$	$\frac{1}{2}\delta(f-f_o)+\frac{1}{2}\delta(f+f_o)$
$\sin(2\pi f_o t)$	$\frac{1}{2j}[\delta(f-f_o)-\delta(f+f_o)]$

Continued .....

Fourier Transform Properties

Let $x(t) \Leftrightarrow X(f)$, $x_1(t) \Leftrightarrow X_1(f)$ and $x_2(t) \Leftrightarrow X_2(f)$; and a, b, t_o and f_o scalar quantities.	
Linearity	$ax_1(t)+bx_2(t) \Leftrightarrow aX_1(f)+bX_2(f)$
Scaling ($a \neq 0$)	$x(at) \Leftrightarrow \frac{1}{\lvert a \rvert} X\left(\frac{f}{a}\right)$
Time Shifting	$x(t-t_o) \Leftrightarrow X(f)e^{-j2\pi f t_o}$
Frequency Shifting	$x(t)e^{j2\pi f_o t} \Leftrightarrow X(f-f_o)$
Modulation	$x(t)\cos(2\pi f_0 t) \Leftrightarrow \frac{1}{2}X(f-f_0)+\frac{1}{2}X(f+f_0)$
Time Convolution	$x_1(t)*x_2(t) \Leftrightarrow X_1(f)X_2(f)$
Frequency Convolution	$x_1(t)x_2(t) \Leftrightarrow X_1(f)*X_2(f)$
Time Differentiation	$\frac{d^n}{dt^n}x(t) \Leftrightarrow (j2\pi f)^n X(f)$
Frequency Differentiation	$(-jt)^n x(t) \Leftrightarrow \frac{d^n}{df^n}X(f)$
Time Integration	$\int_{-\infty}^{t} x(\tilde{t})d\tilde{t} \Leftrightarrow \frac{X(f)}{j2\pi f}+\frac{1}{2}X(0)\delta(f)$
Frequency Integration	$x(t)u(t) \Leftrightarrow \int_{-\infty}^{f} X(\tilde{f})d\tilde{f}$

Useful Trigonometric Identities

$$\sin A \sin B = \frac{1}{2}\left[\cos(A-B)-\cos(A+B)\right]$$

$$\cos A \cos B = \frac{1}{2}\left[\cos(A+B)+\cos(A-B)\right]$$

$$\sin(A+B) = \sin A \cos B + \cos A \sin B$$

$$\cos(A+B) = \cos A \cos B - \sin A \sin B$$

$$\sin\theta = \frac{1}{2j}\left[e^{j\theta}-e^{-j\theta}\right]$$

$$\cos\theta = \frac{1}{2}\left[e^{j\theta}+e^{-j\theta}\right]$$

Continued .....

Table of Bessel functions of the first kind

	$J_n(\beta)$							
n	$\beta = 0.2$	$\beta = 0.3$	$\beta = 0.5$	$\beta = 0.7$	$\beta = 1.0$	$\beta = 2.0$	$\beta = 3.0$	$\beta = 5.0$
0	0.990	0.978	0.938	0.881	0.765	0.224	-0.260	-0.178
1	0.100	0.148	0.242	0.329	0.440	0.577	0.339	-0.328
2	0.005	0.011	0.031	0.059	0.115	0.353	0.486	0.047
3		0.001	0.003	0.007	0.020	0.129	0.309	0.365
4				0.001	0.002	0.034	0.132	0.391
5						0.007	0.043	0.261
6						0.001	0.011	0.131
7							0.003	0.053
8								0.018
9								0.006
10								0.001

End of Paper